FEB 2 1924

No. 7. Vol. XVI. July, 1923.

The ILLUMINATING ENGINEER

ELECTRICITY · ACETYLENE · OIL · GAS

Edited by LEON GASTER

18/- Yearly. THE JOURNAL OF SCIENTIFIC ILLUMINATION. 1/6 a Copy.

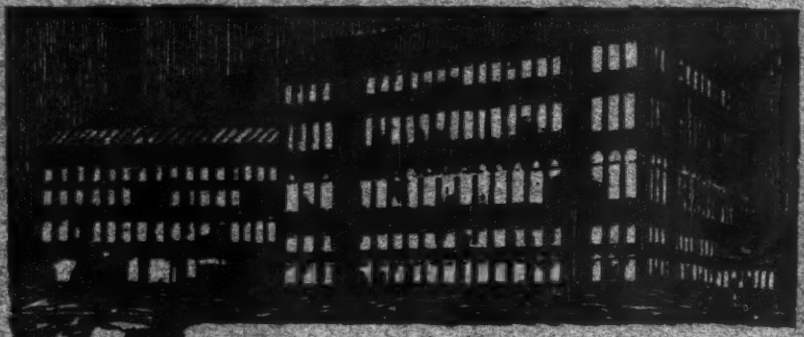
OFFICIAL ORGAN OF THE
Illuminating Engineering Society.
(Founded in London 1909.)

ILLUMINATING ENGINEERING PUBLISHING COMPANY, LTD.
32, VICTORIA STREET, LONDON, S.W.1
(TEL. NO. VICTORIA 5215.)

This number contains an Account of the Proceedings at the **Annual Meeting** of **The Illuminating Engineering Society** on May 24th, 1923, including the Paper read by MR. P. R. ORD, on **"The Comparison of Natural and Artificial Daylight."**

Other matters dealt with include :—

INDUSTRIAL LIGHTING. DEVELOPMENTS IN ART GALLERY ILLUMINATION. THE ENGINEERING AND SHIPPING EXHIBITION, Etc.



THE GAS LIGHT AND COKE COMPANY

will be happy at any time to co-operate fully with any Member of The Illuminating Engineering Society in the planning of the lighting of any room or building situated within their area of supply, and in making any experiments in connection therewith to the end of ensuring its illumination on scientific and practical lines.

Communications addressed to the Chief Office, Horseferry Road, Westminster, S.W.1, and mentioning "The Illuminating Engineer," will receive special attention.

The
ELECTRICITY · ACETYLENE ·
ILLUMINATING ENGINEER
OIL · GAS
Edited by
LEON GASTER

THE JOURNAL OF SCIENTIFIC
ILLUMINATION.

OFFICIAL ORGAN OF THE
Illuminating Engineering Society.
(Founded in London, 1909.)

ILLUMINATING ENGINEERING PUBLISHING COMPANY, LTD.
32, VICTORIA STREET, LONDON, S.W.1.
Tel. No. Victoria 5215.

EDITORIAL.

Tests of Artificial Daylight.

The Annual Meeting of the Illuminating Engineering Society, held on May 24th, was noteworthy for two particularly interesting demonstrations by Dr. Crowley on "The Use of Intermittent Light in Industry," and by by Mr. P. R. Ord on "The Comparison of Natural and Artificial Daylight." We propose to deal with Dr. Crowley's very comprehensive paper in our next issue, and to confine ourselves for the present to the problems raised by Mr. P. R. Ord.

On several occasions during recent years demonstrations of apparatus for producing artificial daylight have taken place before the Illuminating Engineering Society, and we have pointed out the need of some reliable method of testing these different systems, and ascertaining the kind of work for which each is suitable. There is clearly room for different grades of accuracy. In a store devoted to coloured and fancy goods, for example, one may not require quite the same accuracy as is called for in the very exacting work of expert dyers, etc. On the other hand, there are some lighting units which are described as artificial daylight, but can only be regarded as very approximate imitations, and it is necessary to distinguish these from the more scientifically designed and accurate systems.

Mr. Ord's demonstration was therefore timely. He showed how, by the aid of the Nutting-Hilger spectrophotometer we can compare the spectra of two illuminants, or any illuminant and daylight, colour by colour, and ascertain where there is excess or deficiency. But the investigator is hampered by the difficulty that daylight itself is not a constant quantity but varies greatly, both in intensity and in quality. Marked variations in intensity may take place whilst an experiment is in progress, and Mr. Ord showed how such changes might be allowed for by the aid of an ingenious supplementary measuring device. But we have still the difficulty that the *quality* of daylight at different times of the day is not the same and Mr. Ord's curves illustrating the extent of this variation are of great interest. It would appear, however, that the departure of some forms of "artificial daylight" from normal natural light is much greater than the usual variations in daylight itself; the best types of artificial daylight units, on the other hand, appear to approach the limits of possible accuracy.

The process of comparison of artificial daylight appliances would be rendered much easier if we had a reliable standard of "white light." Mr. Ord quoted an account of some efforts in this direction made at the Bureau of Standards, Washington, but the problem has not been completely solved and deserves further investigation. Meantime the spectrophotometer affords a useful means of studying systems of artificial daylight, especially if supplemented by the examination of fabrics dyed in special delicate shades. It is possible to select dyes which match exactly under good daylight conditions but appear quite dissimilar by artificial light. The study of test-pairs of this kind is therefore a useful means of judging the fidelity with which daylight has been imitated.

Assuming that average daylight can be imitated with sufficient fidelity for practical purposes, the next point of importance is *constancy*. An artificial daylight unit might be originally accurate, but its correctness might be impaired by the effect of dust on colours, or by slow changes in the pigments used. Effects of dust should not give rise to trouble in the case of enclosed units in which the light is filtered through panes of tinted glass. But in this case another factor needs to be considered, the accuracy with which such glass can be reproduced. Considerable care is needed to ensure that when the stock of glass is used up the next melting will be identical, as regards colour value, with the original melting.

Finally, we come to the question of intensity of illumination provided. The filters used to produce artificial daylight inevitably absorb a considerable percentage of light, with the result that some of the units involved in the past have yielded an illumination too feeble for most practical purposes. The aim should be to secure both the correct colour and an intensity of daylight comparable with that available during the day. The processes for which artificial light is used are usually "fine" and high illumination, even up to 20-50 foot-candles, is beneficial. So long as we effect the imitation of the colour of daylight by a subtractive process, *e.g.*, by filtering the light through panes of tinted glass, a relatively low efficiency, compared with ordinary illuminants, seems inevitable. Even so, the loss in efficiency is usually of small moment in comparison with the advantages gained. Ultimately we may find more efficient methods, producing directly only the various components of the spectrum in the desired proportions, without having recourse to the wasteful device of absorbing excess of certain colours. This, too, affords a fruitful field for investigation.

Developments in Art Gallery Illumination.

The lighting of picture galleries has for some time attracted the interest of architects and lighting experts, by reason of the special difficulties it presents, and the possibilities of fine effects if these are overcome. There was a discussion on this subject before the Illuminating Engineering Society in 1914, introduced by Professor Silvanus P. Thompson with his inimitable skill. More recently Messrs. Rayner, Walsh and Buckley, in their paper on the "Lighting of Public Buildings in 1922," described some interesting experiments on daylight illumination in art galleries, made at the National Physical Laboratory at the request of H.M. Office of Works.

Hitherto attention has been devoted mainly to natural illumination, and in many picture galleries artificial light is still not used, partly, perhaps, because the problem of providing suitable artificial lighting was formerly deemed insoluble, partly because of an impression that the introduction of artificial illuminants necessarily involved danger of fire to the precious contents of the gallery.

In this country the problem has been rendered more difficult by the fact that we have usually to do with old-established buildings. In the United States, where new art galleries are more frequently erected, there has been some interesting recent experience, some of which is given in a paper by G. T. Kirby and L. X. Champeau before the American Illuminating Engineering Society.* One of the great difficulties in maintaining adequate daylight illumination is the changing inclination of the sun. The authors dealt with this in an ingenious manner by providing a series of adjustable louvres, such that light could always be directed downwards on the diffusing skylight. The skylight was of prismatic glass so designed as to concentrate light evenly on the walls, but also to allow fair illumination in the centre of the room. (It may be recalled that in the discussion in London in 1914 Mr. Joseph Pennell contended that the primary function of the light should be to illuminate the pictures, leaving the centre of the room in comparative obscurity.)

In the American experiments artificial light was provided by artificial daylight lamps, some mounted in suitable inclined reflectors to throw light on the walls, others directed directly downwards, but all mounted in a special enclosure above the ribbed glass skylight. In this way the impression of daylight is better maintained, and the fact of the sources being entirely outside the room has other advantages, notably safety, avoidance of troublesome shadows being cast by the lighting units by day, and elimination of glare from the sources by night. It is stated that the resemblance to daylight was so close that persons present at times when artificial light had been substituted for natural light were unaware of the change.

It goes without saying that the task of the lighting expert is rendered much easier when he has a new building to deal with and the design of the structure and of the methods of illumination can be undertaken hand in hand. But even when one has to deal with existing buildings a great deal may be done by the aid of modern lighting appliances, and authorities in this country should seriously consider the possibility of enabling the public to see our national treasures both by day and by night.

---

† *Trans. Illum. Eng. Soc.*, U.S.A., July, 1923.

The Report of H.M. Chief Inspector of Factories for 1922.

The report of H.M. Chief Inspector of Factories has for many years contained useful comments on industrial lighting, and the recently issued report of Mr. Gerald Bellhouse for 1922 forms no exception in this respect. It is encouraging to note that more consideration is now being paid to suitable methods of lighting, adapted to the varying nature of the work; and that the old idea that every factory can be lighted on a uniform plan no longer appeals to progressive manufacturers. The Joint Industrial Councils appear to be doing good work in promoting agreement on the methods of lighting needed in various trades. A notable instance is the Hosiery Joint Industrial Council, whose representatives agreed that large sums of money are still being expended on brilliant lighting unsuited to the work, and that many manufacturers could reduce their bills considerably, at the same time getting better results, if they studied the question more carefully.

Many of the comments of inspectors refer to glare. A case of a silk factory where girls are employed in examining skeins to detect fault threads, is mentioned. Originally electric lamps in shallow shades were used and the irritating glare of these caused depreciation in the quality of work; when the lights were removed to the ceiling and proper reflectors provided much better results were secured. Attention is specially drawn to the need for good illumination in incandescent mantle factories, where much of the work is of a fine character. For the final burning-off an "anti-glare" screen is now regarded as essential. It is interesting to observe that in some industries subdued light is considered desirable. In some cases this view deserves consideration, but in others it arises apparently from prejudice or ignorance of modern possibilities in lighting. Thus unsatisfactory conditions are reported from certain works, especially in old grinding mills, the contention being that "good" lighting interferes with observation of the polish and finish of the article worked with. This contention, however, is negatived by the experience of one of the largest firms of silversmiths which has erected a new factory with ample lighting facilities, and with no disadvantage to the worker or the quality of his labour. The use of "artificial daylight" lamps appears to be increasing, and according to report they are proving of great value for matching colours.

Several inspectors have commented on the need for fuller evidence of accidents due to faulty or insufficient lighting. A curious accident is mentioned where an operator climbing a vertical ladder grasped at a deceptive shadow cast by an arc lamp with broken globe, thinking that it was the rung of the ladder. As the reports of the Departmental Committee have shown, there is good reason to believe that a considerable proportion of accidents due to inadequate lighting is to be found amongst those classed as "persons falling." This form of accident has hitherto formed a large proportion of the total. Thus in the year 1922, 12,964 out of a total number of reported accidents of 97,986, were of this class. In the case of fatal accidents those due to persons falling (251) form as much as 30 per cent. of the total (843). It is satisfactory to note that the relation of lighting to this form of accident will be the subject of a special inquiry during certain months of the current year, from which, it is hoped, much valuable evidence may be forthcoming.

LEON GASTER.

TRANSACTIONS

OF

The Illuminating Engineering Society.

(Founded in London, 1909.)

The Illuminating Engineering Society is not, as a body, responsible for the opinions expressed by individual authors or speakers.

ANNUAL MEETING.

(Proceedings at the Annual Meeting of the Illuminating Engineering Society, held at the House of the Royal Society of Arts, 18, John Street, Adelphi, W.C., at 7.45 p.m., on May 24th, 1923.)

THE Annual Meeting of the Illuminating Engineering Society was held in the House of the Royal Society of Arts, London, on Thursday, May 24th, 1923, the Chair being taken by Mr. A. P. Trotter.

The Minutes of the last meeting having been taken as read, the HON. SECRETARY read out again the names of applicants for membership announced at the last meeting,* who were formally declared members of the Society.

The HON. SECRETARY then proceeded to read in abstract the usual **Report of the Council** for the Session (pp. 163-166). The subjects dealt with during the past year had afforded excellent opportunities for co-operation with kindred societies and associations. Reference was also made to the considerable amount of work being done by the National Illumination Committee, and to the activities of the British Industrial Safety First Association. A new and revised edition of the illustrated pamphlet, issued by the B.I.S.F.A., on illumination as an aid to safety, was in course of preparation. An event of outstanding importance had been the issue of the Third Interim Report of the Home Office Departmental Committee on Lighting in Factories and Workshops. Papers had been read by Mr. L. Gaster, Mr. Robert Watson and others explaining the recommendations of the Committee. At the paper read by the former before the Royal Society of Arts on May 16th, Sir Malcolm Delevingne, K.C.B. (Assistant Under-Secretary of State, Home Office), gave the welcome assurance that provisions requiring adequate lighting would be included in the next Factory Act. Industrial lighting was also receiving attention at the hands of the Department of Industrial Hygiene of the International Bureau of the League of Nations in Geneva.

The following Resolution was then proposed by Mr. T. E. RITCHIE: "That the Annual Report of the Council for the Session 1922-23 be adopted, and that a vote of thanks be moved to the Council and Officers of the Society for their services during the past session."

Mr. T. E. RITCHIE remarked that the Report indicated conclusively the very wide range of activities of the Society, and expressed the gratitude which members owed to the officers of the Society for their work during the past

* ILLUM. ENG., June, 1923, p. 133.

session—without which the Society could not have achieved anything like the measure of success which it had done. He asked those present to pass the vote of thanks with acclamation. The Resolution, having been seconded by Mr. PILLBROW, was put to the meeting and declared carried unanimously.

Mr. L. GASTER briefly expressed, on behalf of the Officers, their appreciation of the vote of thanks. Their recognition of the confidence on the part of members would encourage them to continue doing their very best in the Society's interests.

The following Resolution was then proposed by The CHAIRMAN, seconded by the HON. SECRETARY, and carried unanimously:—

"That this meeting desires to express a cordial vote of thanks to the Royal Society of Arts for the courteous permission to make use of their rooms during the past session, and records its appreciation of the encouragement and support which the Society has received."

This terminated the formal business before the meeting, and the CHAIRMAN then called upon Dr. J. F. CROWLEY to read his paper on **"The Use of Synchronously Intermittent Light in Industry."** In the early part of his paper the author discussed in some detail the physiological basis of impressions received by the eye when moving objects were viewed by intermittent light. He then proceeded to demonstrate how these effects could be conveniently utilised in practice for the observation of quick running machinery. The introduction of the neon lamps, which responded instantly to each variation in an alternating voltage, had proved of great assistance to these stroboscopic effects. The familiar method of studying the speed of alternating machines by observation of a disc bearing various patterns, illuminated by light from a neon lamp run on alternating current were shown. Dr. Crowley also described and illustrated a variety of devices, notably the "oscilloscope," for studying high speed machines of all kinds. The machine studied was connected to a small alternator which supplied current to a portable neon lamp. By adjusting the electrical conditions in the circuit the rate of fluctuation of the light could be altered within wide limits. By suitable adjustment of this cyclical variation very rapidly moving parts could be caused to appear stationary, or moving very slowly. Thus, movements which were in reality far too quick for the eye to discern could be revealed and studied in detail. This effect, which it was expected would be of great utility in the textile and other industries, was illustrated by the slowing up of the motions of a sewing machine.

The audience expressed great appreciation of the novel and striking experiments accompanying Dr. Crowley's paper, and the CHAIRMAN then called upon Mr. P. ORD to read his paper on the **"Spectrophotometric Comparison of Natural and Artificial Daylight."**

Mr. P. R. ORD explained the use of the Nutting-Hilger spectrophotometer in comparing the spectra of various artificial illuminants or "artificial daylight" with the light from a normal white sky. An important accessory was a device enabling the variations in intensity of daylight during the test to be allowed for, thus eliminating one important source of possible error in such observations. The paper was illustrated by a variety of lantern slides showing the variations in the nature of daylight at different times of the day, and the degree of resemblance between artificial daylight and normal daylight, and the need for a recognised standard of "white light" was pointed out.

In the discussion of these two papers the CHAIRMAN (Mr. A. P. TROTTER), Mr. D. R. WILSON, Mr. P. J. WALDRAM, Mr. J. S. DOW and Mr. L. GASTER took part, the latter pointing out the great importance of scientific tests to enable the accuracy of systems of artificial daylight to be determined.

A vote of thanks to the authors and to the Chairman for presiding terminated the proceedings, after which it was announced that the opening meeting of the next session would take place in November.

REPORT OF THE COUNCIL FOR THE SESSION (November 1922–May 1923).

(Presented at the Annual Meeting of the Society held at the House of the Royal Society of Arts, 18, John Street, Adelphi, W.C., at 7.45 p.m., on Thursday, May 24th, 1923.)

DURING the past Session the Society has undertaken much useful work and extended its influence in new directions. There have been a number of well-attended discussions, dealing with a variety of subjects, several of which afforded excellent opportunities for co-operation with kindred societies and associations.

It will be recalled that at the last Annual Meeting three additions were made to the Council, namely, Dr. J. F. Crowley, Mr. Phillip Sugg and Mr. D. R. Wilson. In addition, Mr. C. W. Sulley, Director of the Electric Lamp Manufacturers Association of Great Britain, Ltd., has joined the Council, filling the vacancy left by the retirement of Mr. J. E. Edgecombe, the late Director.

MEETINGS OF THE SOCIETY.

As on former occasions the opening meeting of the Session, on November 14th, 1922, was devoted to reports of progress and exhibits illustrating developments in illuminating engineering. The usual Report of Progress during the Vacation, presented by the Hon. Secretary, was followed by the Report of the Committee on Progress in Electric Lamps and Lighting Appliances. There was also a varied selection of exhibits, including the Tuck illumination photometer, new types of hospital inspection lamps, pillarless miners' lamps, dust-proof bowl-fittings, blinking effects with neon lamps, etc. Some pleasing photographs illustrating the lighting arrangements in the new Port of London Building, were also shown by Captain W. J. Liberty.

On December 12th, 1922, a discussion on "Recent Developments and Modern Requirements in Street Lighting" was opened by Mr. Haydn T. Harrison, a supplementary note on "Street Lighting and Safety" being contributed by Mr. L. Gaster. The discussion was opportune in view of the general recognition that the time is ripe for the initiation of many schemes of renovation in public lighting, which were postponed during the war and post-war years. Members were very pleased to welcome Mr. A. P. Trotter, who had read a very comprehensive paper on the Street Lighting Specification before the Society in 1913, and who came up to London specially to preside over the meeting. The Society was also honoured by the presence of Dr. Clayton H. Sharp, a Past-President of the Illuminating Engineering Society in the United States, who opened the discussion. Dr. Sharp has since contributed a sympathetic account of the proceedings to the Journal of the Illuminating Engineering Society in the United States, in the course of which he suggested occasional joint discussions of papers of common interest, to take place simultaneously before the Societies in both countries; in some cases it would doubtless be beneficial for a subject to be dealt with in two papers, expressing the standpoints of lighting experts in this country and the United States, and thus forming a useful basis for exchange of views. It is to be hoped that at some future time it will be possible to arrange such discussions, which, as Dr. Sharp remarks, would be of great profit to both Societies.

The next meeting, on January 16th, was devoted to a subject of exceptional interest at the present time—"The Need for Suitable Training in Illuminating Engineering." In an introductory paper Messrs. C. E. Greenslade and J. E. S. White discussed the opportunities of providing suitable instruction in the principles of good illumination in elementary schools and scientific and technical institutions and colleges. Dr. F. T. Chapman, of the Board of Education, who opened the discussion, expressed his sympathy with the objects which the Society had in view; other representatives of colleges and educational institutions agreed that the subject should receive more attention, and welcomed the aid of the Society. Prior to the meeting an inquiry was addressed to a number of leading educational institutions with a view to ascertaining the present position and future prospects. The replies so

far received have indicated a general willingness to consider sympathetically suggestions for courses on illuminating engineering, and to welcome the co-operation of the Society in arranging the syllabus. The discussion gave rise to many useful suggestions, and it is proposed that the whole subject shall receive attention at the hands of a small joint committee, on which the Society and educational bodies will be appropriately represented. Attention was also drawn to the need for a suitable textbook on illuminating engineering, which could be used by students at colleges throughout the country. The preparation of a textbook specially written for this purpose appears highly desirable, and preliminary arrangements to meet the expense of publishing such a work at a moderate price are now being made.

On February 20th a paper was read by Mr. W. J. Jones and Mr. E. A. Marx, Jr., on "The Projection of Light," in which an account was given of some experiments with gasfilled lamps as sources for use with optical lanterns, and various other problems, such as those met with in projecting light in kinema theatres, in flood lighting, etc., were also discussed. In the course of the discussion an interesting demonstration was given by Major Adrian Klein of his new colour-projector, Mr. J. Eck exhibited some novel forms of arcs for projection purposes, and Mr. Haydn T. Harrison described some of the researches which he had made when developing searchlights with cooled electrodes for the British Navy during the war.

The next meeting, on March 27th, was devoted to a paper by Messrs. P. J. and J. M. Waldram on "Window Design and the Predetermination of Daylight Illumination." A special invitation to attend the meeting was conveyed to members of the Royal Institute of British Architects and the Surveyors' Institution, and the former body (following the precedent established in connection with the discussion on the Lighting of Public Buildings in the previous session) has arranged to publish an abstract of the paper in their official journal for the benefit of the R.I.B.A. Apart from its value in elucidating a subject which is of common interest to architects and illuminating engineers, the paper contained a useful history of work in this field to date, including the pioneering experiments of the Society's Joint Committee on Natural Lighting in Schools, which reported in 1913, and the more recent investigations of the National Physical Laboratory.

The paper by Mr. L. Gaster on "The Lighting of Printing Works," on April 24th, served as a useful supplement to the papers read before the Society by Mr. F. W. Goodenough and Mr. J. Eck in 1912. The conditions of illumination desirable for various printing processes were discussed by the aid of illustrations of typical modern installations, and special attention was drawn to the needs of the editorial and journalistic departments. A general invitation to the meeting was conveyed to the Institute of Journalists, the Joint Industrial Council of the Printing and Allied Trades of the United Kingdom, the Federation of Master Printers, the London Society of Compositors and other bodies concerned with printing processes. The discussion was opened by the Rt. Hon. C. W. Bowerman, M.P., a Past-President of the Joint Industrial Council, and Messrs. A. E. Goodwin and A. E. Holmes, joint secretaries of the Council, also cordially welcomed the assistance of the Society in dealing with this complex problem. Amongst others who joined in the discussion may be mentioned Mrs. A. Bridge (Chairman of the Health Committee of the Joint Industrial Council) and Mr. G. A. Isaacs (Secretary of the National Society of Operative Printers and Assistants). It was generally agreed that this meeting furnished a conspicuous example of the useful practice of the Society of inviting the co-operation of those actually engaged in the industrial process, the lighting of which was being considered. The meeting was presided over by Mr. F. W. Bridges, who took an active interest in the arrangements for the meeting, and whose familiarity with the printing industry contributed considerably to the success of the discussion.

Following the presentation of this report a paper on "The Use of Synchronously Intermittent Light in Industry" is to be presented by Dr. J. F. Crowley, and a demonstration of the Spectro-

photometric Comparison of Natural and Artificial Daylight is to be given by Mr. P. R. Ord. The paper by Dr. Crowley will deal with various stroboscopic phenomena which have recently been usefully applied to various industrial problems, and Mr. Ord's contribution is timely in view of the frequent references made to Artificial Daylight at meetings of the Society during recent years. The proceedings at the Annual Meeting will thus form a fitting conclusion to a very varied series of papers and exhibits.

Co-operation with Other Bodies.

The arrangement whereby the Presidents of kindred bodies become Members of Council of the Society during their tenure of office now applies to the following bodies, whose co-operation continues to be of service in dealing with problems of mutual interest :—

The Illuminating Engineering Society in the United States ; the Illuminating Engineering Society in Japan ; the Institution of Gas Engineers ; the Institution of Electrical Engineers ; the Council of British Ophthalmologists ; the Ophthalmological Society ; the Physiological Society ; the Electrical Contractors Association ; the Society of British Gas Industries ; and the Association of Railway Electrical and Telegraph Engineers.

The National Illumination Committee of Great Britain has recently done a considerable amount of useful work, which is summarised in the report of the Chairman for the past year. This report, together with an official translation of the French text of the Photometric definitions adopted at the First Technical Congress of the International Illumination Commission last year, has been issued in pamphlet form and will appear in The Illuminating Engineer shortly.

In addition to the work being done on such matters as units and nomenclature, a sub-committee has been appointed to review existing recommendations in different countries on the avoidance of glare from motor headlights. Arrangements have also been made for the formation, by the British Engineering Standards Association, of a sectional committee to which problems connected with the standardisation of lamps and lighting appliances can be referred.

The representation of the Society on the various committees of bodies concerned with the " Safety First " movement dealing with lighting has again been instrumental in promoting the study of illumination in relation to safety in streets and factories. Attention has recently been devoted by the British Industrial Safety First Association to the analysis of accidents in factories, reference to which is made in " Safety First," the journal of the Association, now being issued in a new and expanded form. A contribution by Mr. L. Gaster to this journal recently emphasised the desirability of classifying accidents with a view to establishing more fully their relation to inadequate lighting, particularly as regards accidents due to persons falling, and this matter will doubtless receive attention from the Association in due course.

The stocks of the illustrated pamphlet, prepared by Mr. L. Gaster for circulation by the Association, summarising the main principles of good illumination, and emphasising its importance in the interest of safety, having become exhausted, a new and revised pamphlet is now in course of preparation and will, it is hoped, be available for distribution in the near future.

Developments in Industrial Lighting.

An event of outstanding importance in connection with industrial lighting has been the issue of the Third Report of the Home Office Departmental Committee on Lighting in Factories and Workshops, the contents of which were fully summarised in the special issue of The Illuminating Engineer dated July, 1922. It is hoped to arrange for papers before leading scientific societies and trade associations with the object of making the aims of the Departmental Committee more widely known, and a useful opportunity of doing so was afforded by the discussion before the Society on the " Lighting of Printing Works " on April 24th, to which reference is made above. Mr. Robert Watson, in a paper delivered at the Eleventh Annual Conference of the British Commercial Gas Association during October 16th-18th, 1922, also gave a useful summary of these require-

ments. The Royal Society of Arts, which has made a practice of reviewing progress in this field at intervals of a few years, provided another opportunity of making the aims of the Home Office Departmental Committee more widely known in the paper on "Industrial Lighting and the Prevention of Accidents," read by Mr. L. Gaster on May 16th. Sir Malcolm Delevingne K.C.B., Assistant Under Secretary of State, Home Office, who presided, referred in sympathetic terms to the importance of adequate industrial lighting. He also gave the gratifying assurance that in the near future the recommendations of the Home Office Departmental Committee would be embodied in the Factory Acts of this country, so that illumination will rank with heating and ventilation as an essential element in the interests of safety, health and efficiency of work.

The discussions before this Society have had a beneficial effect in arousing interest in the subject of industrial lighting, and the efforts of the Society in this direction have been greatly aided by the sympathetic attitude of the Press, which has done useful service in giving publicity to conclusions arrived at. There is, however, still need for educational propaganda, and the participation of Joint Industrial Councils in determining the methods of lighting best suited to their respective industries is much to be desired. It is satisfactory to observe the development of interest in illuminating engineering on the part of leading firms concerned with the manufacture of lamps and lighting appliances, which are also in a position to do useful educational work in making the principles advocated by the Society better known.

It will be recalled that the subject is also receiving attention at the hands of Dr. L. Carozzi, a valued corresponding member of the Society who is associated with the Department of Industrial Hygiene of the International Labour Bureau of the League of Nations at Geneva. The Minister of Labour in France has also appointed a committee to deal with the matter.

In previous reports reference has been made to the valuable work being done by the Industrial Fatigue Board, and in particular to the inquiry initiated by this body into conditions in the silk weaving industry, which led to the conclusion that the output was 10 per cent. less by artificial light than by daylight. This result has since been corroborated by similar investigations in the cotton and fine linen weaving industries, where the output by artificial light was again found to be 5-12 per cent. less by artificial light than by daylight. Some useful investigations undertaken by the National Institute of Industrial Psychology have shown how slight modifications in the procedure of work have resulted in greater outputs. Better lighting was found to be one of the chief factors contributing to greater ease of work, and in certain industries, such as sweet-packing, the improvement in illumination led to an increase in output of 10-14 per cent. Another instructive example of the effect of light on output is afforded by a recent investigation in a coal mine, conducted by Messrs. R. Farmer, S. Adams and A. Stephenson, and summarised in a recent issue of the Journal of the National Institute of Psychology. It was found in this investigation that by using a lamp of four times the weight of the ordinary lamp, but affording four times as much light, an increase in output of over 14 per cent. was obtained.

Thus every year adds to the evidence available as to the importance of good illumination in factories.

FUTURE PROSPECTS OF THE SOCIETY.

The past Session has thus afforded gratifying evidence that the aims of the Society are becoming more widely recognised, and that there is much useful work before it. The Society can doubtless continue on the present lines, but it is becoming increasingly clear that, in order that it may take full advantage of the opportunities presented, a considerably higher revenue must be obtained —either by increase in membership or in the form of contributions from bodies that benefit by the work on which the Society is engaged.

The Council are now preparing the programme of papers for the next Session, and invite suggestions from members who are prepared to read papers.

JOHN HERBERT PARSONS, *President.*

LEON GASTER, *Hon. Secretary.*

THE SPECTROPHOTOMETRIC COMPARISON OF ARTIFICIAL DAYLIGHT WITH NATURAL NORTH SKY LIGHT.

By P. R. ORD.

(Paper read at the Annual Meeting of the Illuminating Engineering Society held at the House of the Royal Society of Arts, 18, John Street, Adelphi, London, W.C., at 8 p.m., on Thursday, May 24th, 1923.)

THE matter I propose bringing before you is one that has apparently absorbed a great deal of public interest, particularly within the last three or four years. It would appear from the increasing number of manufacturers of artificial daylight apparatus that there is an increasing demand for these types of lamps.

It is unfortunate that natural daylight, the basis upon which the artificial daylight manufacturer must build, is a varying, inconstant and ill-defined quantity; especially so in this country. It is therefore hardly surprising that various makes of artificial daylight lamps emit very widely different approximations to their supposed master; each manufacturer selling his own particular brand of daylight.

It would seem desirable, therefore, that an illuminating engineer in his advisory capacity should be able to discriminate positively the degree of approximation which an artificial daylight lamp bears to the natural daylight of the locality. In no lesser degree also the manufacturer desires a more definite control over his products.

If it were possible to produce some source, or sources, of light which would reproduce natural daylight and reproduce and standardise its spectral energy curve, then the manufacturer's task would be more simple, and the task of examining the relationship of the artificial daylight to the standard daylight would be quite positive and quite simple too. Such a standard has been proposed by Priest based upon the attempts made by Abbot at the Smithsonian Institute to obtain a true representation of the distribution of energy in natural daylight.* Whether Priest's suggestions can be utilised in a practical manner remains to be shown.

If one endeavoured to obtain a simple direct spectrophotometric comparison between an artificial daylight lamp and light from the north sky the result would possibly be a curve as shown in Fig. 8. But one must realise that a second determination may easily be different from the first in every ordinate. It is apparent, therefore, that direct measurement is an unsuitable method by which a true comparison should be made.

We propose that an indirect attack should be made upon the problem in the following way:—

(1) Obtain a spectrophotometric approximation of the variation in colour value of natural daylight throughout a definite period of one day.

(2) Obtain spectrophotometric values of an artificial daylight as compared with natural daylight and at the same time obtain photometric values of this varying natural daylight as compared with the same artificial daylight. One can then apply an accurate correction that will eliminate errors in apparent intensity due to the natural fluctuations in the intensity of natural daylight during time of observation.

The first proposed experiment will supply the "order of magnitude" of the relative variation in colour value of natural daylight throughout several days and so give limits beyond which one can safely say that the artificial daylight lamp under test is an inferior product or not.

The second proposed experiment will give the true deviation of the artificial daylight lamp from natural North Sky daylight; to which the above-mentioned

*See abstract in ILLUM. ENG., Oct., 1922, p.282.

pre-determined limits can be supplied and a value assigned to the efficiency of the particular lamp under test.

Apparatus used.

To obtain values as outlined in experiment (1) we propose using a Nutting-Hilger Spectrophotometer which is seen shown in Figs. 1 and 2. The upper half illustrates in outline the general arrangement of the apparatus and the lower half demonstrates diagrammatically the internal optical train.

Two beams of light enter the photometer box at apertures 1 and 2 respectively and are plane polarised, by the Nicol prisms 3 and 4 at planes situated at right angles to one another. Light from aperture 1 is then twice reflected by the prism 5 and rendered coincident with the beam from 2.

Both beams now travel through the small lens 6 and a rotatable Nicol prism 7 and are focussed upon the telescope object glass 10 through the agency of lenses 8 and 9.

By rotating the Nicol prism 7 the intensity of the beams 1 and 2 as received upon the object glass 10 is varied in respect to each other according to a definite law dependent upon the angle through which the Nicol prism 7 is rotated, such that

$$\frac{I_o}{I} = \text{Tan}^2\theta$$

and $$\text{Log.}\ \frac{I_o}{I} = 2\ \text{Log. Tan}\ \theta$$

$$= \text{D (Density)}$$

Where I_o = Intensity of light entering aperture 1.

Where I = Intensity of light entering aperture 2.

Where θ = Necessary rotation of Nicol prism 7 in order that light from apertures 1 and 2 shall be equal.

Means are thus supplied of measuring the relative intensities of the light falling upon the aperture 1 and the aperture 2.

In order that the two beams may be brought together for accurate estimation of intensity the bounding edge of beam (1) (which is the edge of the prism 5) is focussed as a circular patch of light divided into halves by lenses 6 and 8 upon the slit (11) of a Hilger Spectroscope, as indicated in the small diagram 19.

The light which passes through the slit from this patch is dispersed into its various colour components by the prism 16. It again appears as a spectrum at the focus of the eyepiece of the spectroscope as seen in the small diagram at the bottom of the illustration.

By adjusting two shutters 14 and 15, at the focus of the spectrum one can isolate from the spectrum an apparent monochromatic patch of light, then by rotating the prism 16 by means of the micrometer screw 17 any desired colour can be brought under examination between the shutters 14 and 15, and its exact wavelength recorded from the drum of the micrometer screw.

In addition, therefore, to the determination of the relative intensities of the two beams entering the apertures 1 and 2 we can make this determination for any particular wavelength or colour of which the two beams are composed.

Method of Measurement.

With the apparatus adjusted as described two beams of equal intensity from a common light source are allowed to fall upon the apertures 1 and 2. The Nicol 7, which is held in a divided circle 18, is rotated until the top and bottom halves of the colour patch seen in the eyepiece are judged equal in intensity. The position of the circle and micrometer screw is then recorded.

A series of such measurements for various wavelengths will give one the correct zero position of the circle for any part of the spectrum, as shown in Fig. 11.

Natural daylight is now reflected from the North Sky into the aperture 1 and light from a 6-volt lamp (energised by a large capacity accumulator to ensure a constant candle power and colour value) passes through the aperture 2.

One now proceeds to record the relative intensity of the Natural Daylight with that of the 6-volt lamp for wavelengths 6,700, 5,400 and 4,700 A.U.

in the same manner as the zero curve was obtained.

These measurements must be taken in rapid succession at favourable opportunities and at frequent intervals during the day.

maximum and minimum peaks of the curves in each of the three days are shown in tabular form in Fig. 6.

An examination of this table will show that the ratio of intensity existing between the red, green and blue com-

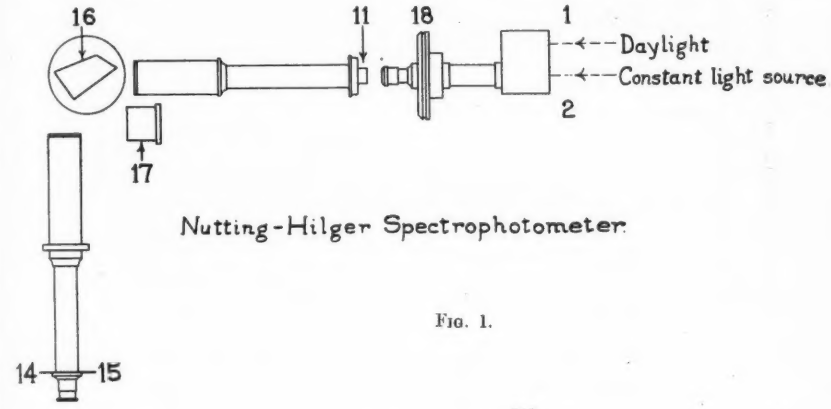


FIG. 1.

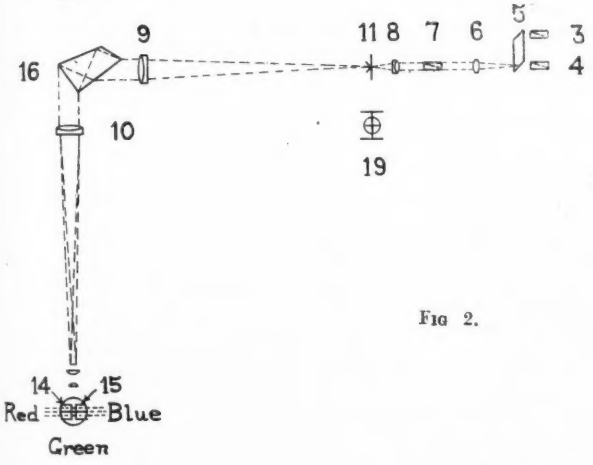


FIG 2.

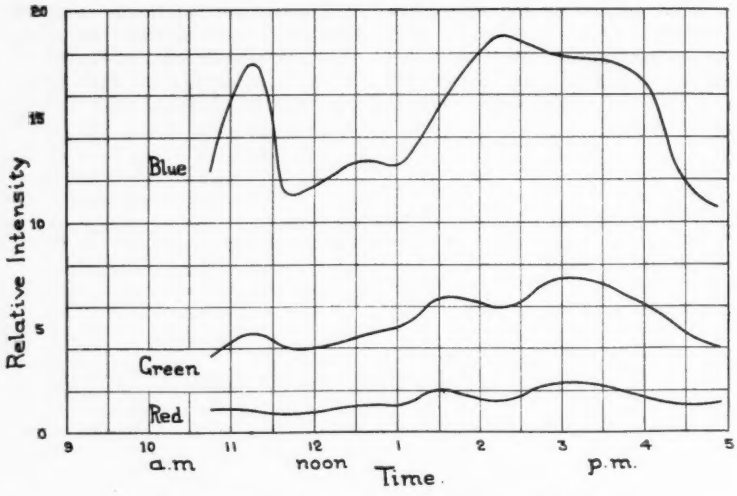
Results.

The results of three separate day observations are shown in Figs. 3, 4 and 5. (The latter being taken from approximately sunrise to sunset.)

Upon inspection of these diagrams it will be noticed that between 8 a.m. and 6 p.m. in each of the three cases the proportionality of blue to green to red remains within certain limits although the brightness of the daylight has altered 300 per cent. or more. The ponents of natural daylight probably vary by about 30 per cent. in extreme cases of low or high daylight brightness of North Sky light.

In conclusion, therefore, we can say that for first approximations an artificial daylight lamp must resemble North Sky natural daylight within these definite limits.

We will now proceed to the second stage of the investigations, that is, the experiment as previously outlined, to



Curves showing relative intensities of the red, green and blue components of natural daylight as compared with a 6 volt gas filled lamp at various intervals throughout one day.

FIG. 3.

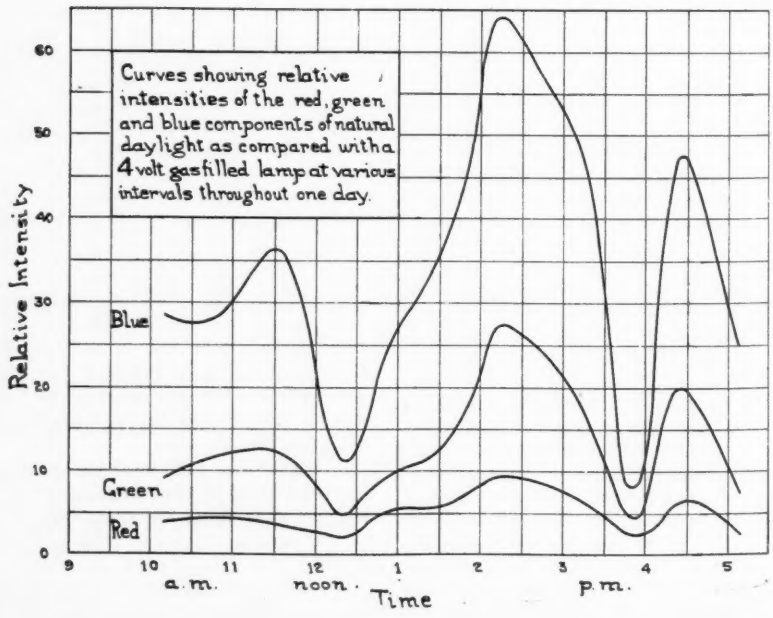
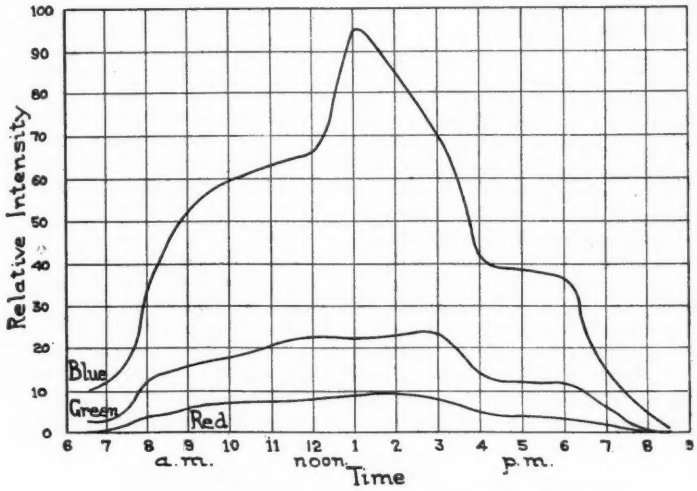


FIG. 4.



Curves showing relative intensities of the red green and blue components of natural daylight as compared with a 6volt gas filled lamp at various intervals throughout one day.

FIG. 5.

		Max.&Min. Photometric Intensities. Between 10%–6% [Summer Time.]			Ratio of Relative Intensity				
		Time	Relative Intensity	Percentage Increase	Red 6700λ	Green 5500λ	Percentage Increase (+) or Decrease (–)	Blue 4700λ	Percentage Increase or Decrease
Curve 3	Max.	2-50	2·110	+ 228	1	3·41	+ 29·5	8·5	+ 45%
	Min.	11-40	0·925		1	4·43		12·3	
Curve 4	Max.	2-15	9·55	+ 467	1	2·88	– 25·5	6·75	– 25
	Min.	12-20	2·04		1	2·30		5·42	
Curve 5	Max.	1-0	9·00	+ 300	1	2·51	+ 31%	10·65	– 3
	Min.	6-0	3·00		1	3·27		10·35	

Summary of results demonstrating the relative color value of natural daylight at the photometric maximun and minimun peaks of curves 3, 4 & 5.

FIG. 6.

determine the degree of approximation any particular artificial lamp bears to North Sky light.

Apparatus.

The apparatus is as described for the first experiment but in addition a second photometer is used in conjunction with it, as shown in Fig. 7. The function of this second photometer is to record independently the variation in brightness which is taking place in natural daylight while the artificial and natural daylight are being compared spectrophotometrically by the first instrument. It should be here noted that owing to the colour difference existing between artificial daylight lamps and natural daylight it is necessary to provide the second photometer with a monochromatic filter as shown at 21.

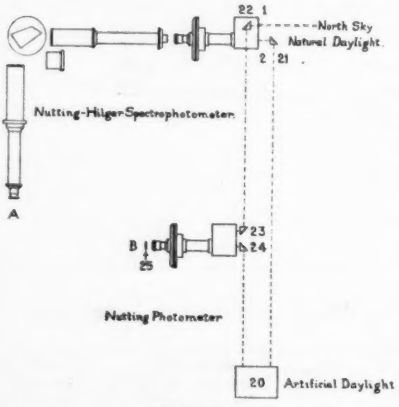


FIG. 7.

Method of Measurement.

We again reflect into aperture 1 light from the North Sky and into aperture 2, by means of the totally reflecting prism 21, light from an artificial daylight source 20.

A relative spectral energy relationship between these two sources can be obtained in the manner described in the previous experiment, but this relationship will not be truly representative since it will contain errors due to the continual alteration of the brightness of natural daylight during observations. We therefore make a further comparison between the same artificial daylight source and the same portion of the North Sky, considering the former as a constant and expressing the intensity value of the North Sky light in terms of it. The North Sky light is reflected into the second photometer by the totally reflecting prisms 22 and 23 and light from the artificial source by the prism 24. Measurements are taken upon these two instruments simultaneuosly by two observers A and B (see Fig. 7).

Results.

The spectrophotometric measurements obtained by observer A are shown graphically in Fig. 8. It will be noticed that the curve which represents the relationship between artificial daylight and the variable natural daylight is very irregular in form.

The measurements obtained by B giving the exact amount of the variation in daylight for every recorded point embodied in A's measurement are shown in Fig. 9. One must note that the absiscæ on this curve are expressed as wavelengths representing the wavelength, as shown on curve 8, to which the daylight photometric value on curve 9 refers.

In Fig. 10 is shown the spectrophotometric zero curve of the first photometer, which must only be regarded as an instrumental error, and having no other significance in reference to these results.

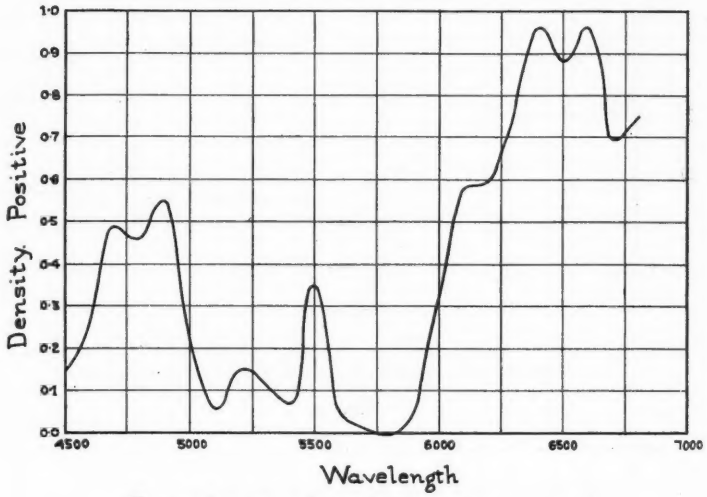
If we now apply the corrections to curve 8 as denoted by curves 9 and 10, a further curve (see Fig. 11) is obtained representing the true spectrophotometric relationship between the artificial lamp and the North Sky light.

The foregoing results have been expressed in logarithmic density but in Fig. 12 the same final result has been converted and expressed in " percentage relative intensity."

Conclusion.

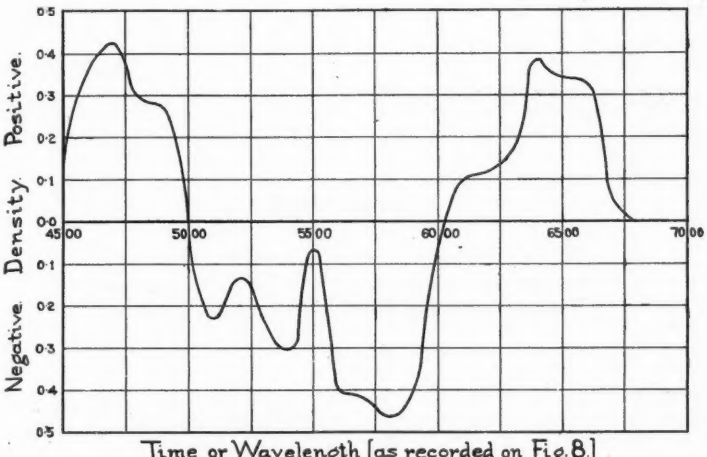
Upon Fig. 12 has been indicated, by two parallel lines, the very generous limits of divergence, as determined by the first experiment, within which the final curve representing the divergence of artificial daylight from natural daylight should fall.

It is quite obvious that the artificial daylight under consideration is many



Curve showing relationship between natural daylight and artificial daylight as obtained by observer A embodying errors due to alterations in intensity of natural daylight and necessary photometer zero corrections see curves 9&10

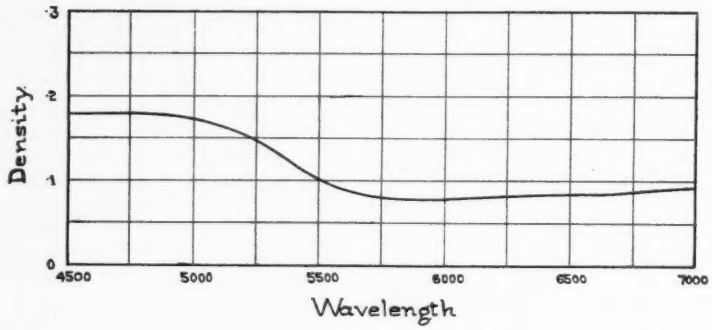
FIG. 8.



Time or Wavelength [as recorded on Fig. 8.] when density was measured.

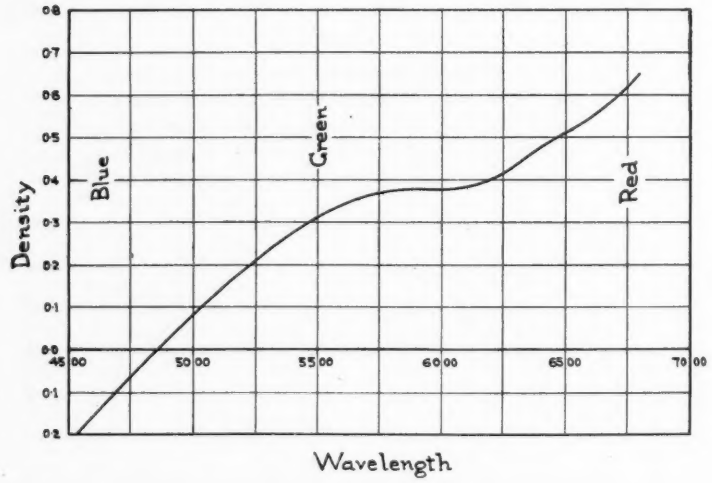
Curve showing the relationship between artificial daylight and natural daylight as obtained by observer B simultaneously with observer A

FIG. 9.



Spectrophotometric zero error of photometer

FIG. 10.



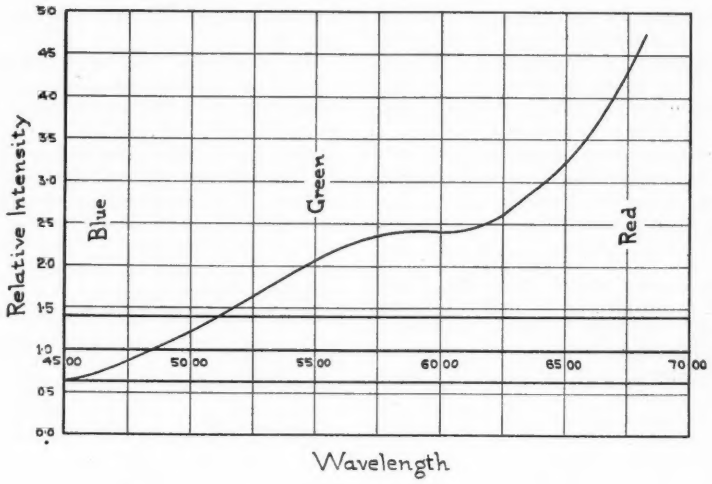
Curve showing true relationship between natural daylight and artifical daylight as obtained from Fig 8, embodying corrections due to Fig. 9 & 10.

FIG. 11.

times remote from these limits. The red portion is 300 per cent. or 400 per cent. too great in intensity, and the green also too intense, and the colour of this particular artificial daylight lamp does not resemble natural North Sky daylight within the reasonable range of variation of the said daylight itself.

I would wish to hereby acknowledge the work done by one of our assistants, Mr. A. J. Woods, to whom credit is due for careful manipulation of apparatus and accurate observations throughout this research.

[*Research Laboratory*,
ADAM HILGER Ltd.,
75a, Camden Road,
*London, N.W.*1.]



Same curves as Fig 11, but expressed in terms of relative intensity, instead of logarithmic density

FIG. 12.

DISCUSSION.

The CHAIRMAN (Mr. A. P. Trotter) recalled that artificial daylight had been discussed before the Society on various occasions. He himself had been interested in the subject at quite an early stage* and still believed that the best procedure was to effect the correction of the light by means of coloured glass. The blue-green glasses he had originally used had been too thick and absorbed too much light, but he could obtain a perfect match with daylight—at certain times. The great difficulty was the extreme variability of daylight itself so that there was not a perfect match at all times of the day. One had, in the first place, to consider what form of daylight one desired to imitate. Even assuming that one confined oneself to a "north light" one still found extreme variations, according to the state of the sky and the clouds. But he had found variations which it was very difficult to explain. In general the quality of daylight seemed to be appreciably more blue in winter than in summer.

He was much interested in the curves exhibited and he would like to have an opportunity of studying them more closely. No doubt the comparison of two illuminants colour by colour with the spectrophotometer was a useful scientific test. But the curve of sensitiveness of the average eye throughout the spectrum was now familiar, and one was disposed to draw from it the conclusion that the light at the extreme ends of the spectrum was of small consequence visually.

The question of testing the correctness of artificial daylight was an extremely important one, as the opportunities for such systems were now very much greater than in the past. When, many years ago, he had tried to induce manufacturers to take an interest in the subject the results were very disappointing. His own experiments were made largely with a box with an aperture through which one could inspect a series of colours illuminated by artificial daylight. Each shade could in turn be brought opposite the peephole and could be viewed simultaneously by

* Proc. Inst. E.E., Vol. xxi., 1894.

daylight and by the illuminant studied, with a photometric device for adjusting the intensity of illumination. He was inclined to think that at the present day some simple testing device of this kind, involving observation of various pigments or dyes, would appeal more directly to users than spectrophotometric curves, however valuable the latter might be to the expert.

Mr. J. P. WALDRAM said that the thanks of the Society were due to Mr. Ord for introducing a most important subject, viz., some definite means of indicating the relative value of the many forms of daylight lamps at present on the market. One point which he had not quite grasped during the reading of the paper was the precise nature of the natural daylight that Mr. Ord proposed to balance lamps against. Apparently it was north skylight with 20 per cent. allowance made for the variations which one found in north skylight during an average day. If so, was it measured with or without clouds? It was important to recognise that the daylight which the makers of daylight lamps professed to imitate was always changing, not only in intensity but also in colour.

Buyers of daylight lamps, and still more professional men who had to advise buyers, were badly in need of some definite standard. It was easy to obtain a lamp for testing purposes, but how was it to be tested? What was it to be tested against? He presumed that the instrument shown tested against a definite type of sky, viz., north skylight probably without clouds, not against any artificial illuminant. He thought it would be very desirable if some artificial illuminant could be taken as a basis, but what appeared to be more desirable than anything else in defining a standard for daylight lamps was a curve of relative intensity of the luminosity of the different parts of the spectrum of the lamp given. He would like to know whether it would be possible to submit daylight lamps to Messrs. Hilger to be tested with this instrument, because it was obviously a somewhat expensive one, which the ordinary practitioner could scarcely hope to possess.

He would also like to ask Mr. Ord whether he had investigated with this instrument the efficacy of any simple practical test for daylight lamps not involving a spectrophotometer. Before the war a German firm of dye makers in Bremen had produced a bundle of fabrics dyed with carefully selected colours that showed obvious discrepancies in anything except a north skylight. These discrepancies were not very marked in sunlight, but under any form of artificial illuminant, even an arc lamp, they were very marked. He suggested that a device of this kind might form a basis of a definite and stringent test to which any daylight lamp could be subjected.

It was not generally recognised by those who sold daylight lamps that you could not correct an ordinary gas filled lamp bulb to any form of daylight without a loss, and the more you corrected the more you lost. If you corrected to sunlight you suffered a loss of, say, 60 or 70 per cent.; if to a north skylight it was impossible to do so without a loss of at least 70 or 80 per cent. Daylight lamps, however, were not so extremely uneconomical as these figures would suggest. With other lamps used for ordinary purposes of illumination we suffered a considerable loss by unscientific reflectors, and a great deal more by ornamental fringes; so that daylight lamps were not so seriously less economical than many other forms of lighting appliances in use.

It need scarcely be pointed out that daylight lamps had a field of great usefulness in industries where the colour difficulty was important. In addition there were scattered up and down the country a number of extremely valuable art collections, which could rarely be seen properly because they were in places which only enjoyed a few days of suitable daylight during the year. Anyone who had tried to see the pictures in, say, the Municipal Art Gallery at Manchester would appreciate what this meant.

Mr. J. S. DOW (Hon. Asst. Secretary) said that he had been struck by the

great variations in the quality of daylight during the day, which seemed to suggest that in judging artificial daylight one must allow far more latitude than was generally supposed. However, after making allowances for all errors of observation, some of the curves shown by Mr. Ord comparing artificial and true daylight showed a very marked divergence, apparently amounting to some hundreds of per cent. in red or blue. He (Mr. Dow) did not think that one could possibly call this "artificial daylight." He presumed that these sources were not regarded as accurate imitations of daylight as he had seen curves which suggested much closer resemblance.

He agreed with Mr. Waldram regarding the great need for a standard white light. The device enabling a compensation for variation in intensity of daylight during the test was a serviceable addition to the spectrophotometer. Spectrophotometric examination was an invaluable means of comparing the merits of different types of "artificial daylight." But he was inclined to think that, for a complete test, supplementary examination of delicate dyes was desirable. He understood that by careful selection of the dyed fabrics one could detect small local deviations from the spectrum of daylight, the effect of which would perhaps not be sufficiently realised from a spectrophotometric test.

Mr. P. R. ORD :—

In reply to the chairman's remarks I do not think that the ends of the spectrum can be ignored. The solar spectrum is the standard to which the lamp maker must work. Recognising the spectral sensitivity of the eye, I do not advise that any part of the spectrum would receive less consideration than another if the artificial daylight is to bear a colour test, for instance, as outlined by Mr. Waldram.

The colour variation of natural daylight is so small compared with the colour variation in natural daylight lamps that I consider the extreme limits of variation of natural daylight here determined to be sufficient tolerance for the present.

In reply to the questions raised by Mr. Waldram's very comprehensive summary I would state that :—

(1). In the case of the first experiment the three sets of determinations were made against

(*a*) Blue sky;

(*b*) Variable white clouds in a totally overcast sky;

(*c*) A totally overcast north sky as representing unfavourable conditions.

(2). The second experiment was made against north sky as at "*c*."

(3). Messrs. Adam Hilger, Ltd., are prepared at any time to carry out these tests on any particular lamp.

(4). A fabric test does not possess any quantitative value.

In agreeing with Mr. Waldram's remarks regarding the usefulness of daylight lamps in the industries, I would like to add that when the technical difficulties have received correct treatment and are overcome, and users have been instructed how to use the lamps correctly, the artificial lamp will very probably displace the natural daylight where constancy of colour value is desired.

Mr. Dow expressed surprise at the large deviation of the artificial daylight from natural daylight and I would say that the particular lamp in question happened not to be the best obtainable. Spectrophotometric tests would not be less sensitive to small local deviations from the solar spectrum, since observations can be made at any small increment of wavelength. Furthermore, a spectrophotometric test is a complete analysis, both positive and permanent.

In conclusion, I beg to thank the Chairman, Mr. Gaster and the Council of the Illuminating Engineering Society for the privilege of putting these results before you, and I trust that they may prove useful to those whom they concern and interesting to the other members of the Society.

STANDARD COLOURED SOLUTIONS.

In a recent contribution to the Optical Society of America, Mr. A. P. Harrison describes experiments with a series of 29 tubes filled with solutions of safranin, with progressively increasing concentration and corresponding depth of colour. In order that the colour of each tube should just differ perceptibly from its neighbour, the increase in concentration had to follow a geometric series, and the same relation was found to hold for solutions of other coloured materials.

THE PLOTTING OF SPECTROPHOTOMETRIC DATA.

IN a paper on the above subject read before the American Illuminating Engineering Society, Mr. Frank A. Benford raises a number of points in regard to the plotting of spectrophotometric data.* It is clearly desirable that the same methods should be used by different observers so that results may be comparable.

The first point that arises is the range of wavelength that should be included. The eye is sensitive to radiations of wavelength 0·39μ to 0·77μ, but for all ordinary purposes the limits are better placed at 0·42μ to 0·68μ; beyond these values the luminous effect is so small as to be of little practical value and accurate testing becomes very difficult. It is convenient to arrange the scale to read from 0·4μ to 0·7μ even if the data only covers a portion of this region.

It is also desirable that the colour boundaries should be indicated, as many people not conversant with spectrophotometric data have but a vague idea of the colours within certain limits. While the accepted range of primary colours includes seven (violet, indigo, blue, green, yellow, orange and red) there are very few people who can distinguish indigo, and the author accordingly suggests the following classification.—

Below 400μ ultra-violet.
0·400μ to 0·424μ violet.
0·424μ to 0·492μ blue.
0·492μ to 0·575μ green.
0·575μ to 0·585μ yellow.
0·585μ to 0·647μ orange.
0·647μ to 0·700μ red.
above 0·700μ infra-red.

It would be a great convenience to have these colour boundaries marked in some manner on all spectrophotometric webs.

Next there is the question of the choice of units for designating wavelength. There are, unfortunately, three distinct methods. There is the *micron* or 10^{-6} metre designated by μ. A second scale is the 10^{-9} metre designated by $m\mu$. Then there is the Ångstrom scale (10^{-10} metre) which is universally employed on precision measurements of wavelengths where there may be as many as seven or eight significant figures. The illuminating engineer is seldom concerned with values beyond the third figure. The micron scale is therefore better for his purpose as no more than two significant figures need to be marked at the foot of each ordinate. This gives a wavelength accurate enough for all ordinary purposes.

There are two methods of plotting spectrophotometric data. One may give the relative *energy* for each wavelength throughout the visible region. This of course gives no indication of the *light* afforded, and is apt to lead to too much importance being assigned to radiation at the ends of the visible spectrum. We may reduce the energy curve to a curve of light by multiplying the energy values by the visibility at different wavelengths; or we may obtain the values of light by measurement and plot them direct. The drawback of this method is that, owing to the much greater luminosity in the central region of the spectrum, curves tend to lose their characteristic outlines; hence variations easily visible in the energy curve are masked. Both methods have their uses, and Mr. Benford in the original paper shows how various derived curves may also prove valuable in certain cases.

In comparing the distribution of light in the spectra of various illuminants it is convenient to make all emission curves pass through unity at some agreed point. Formerly it was customary to make all curves intersect at 0·59μ. It was then believed that this was the point of maximum luminosity. But later work has shown that under normal illumination the peak of the visibility curve lies at 0·556μ. It is therefore better to use 5·550μ as the common crossing point, especially as this is exactly mid-way between the limits of the visible spectrum (0·4μ and 0·7μ). A further reason for preferring this point is to be found in the fact that the maximum of light-curves for modern illuminants has moved towards the blue,

* *Trans. Illum. Eng. Soc.*, U.S.A., Jan. 1923, pp. 69–92.

owing to their higher temperatures and is now usually located near 0·55μ; whereas the maximum for the candle and older illuminants was near 0·59μ, the crossing point formerly selected.

Special points arise in the plotting of discontinuous spectra. Here it is difficult to represent distribution of energy from a complex spectrum in detail. A smooth curve may, for effect, be drawn through the observation points; but as a matter of principle the observation points should be left marked on the diagram. In testing with a continuous spectrum the observer has considerable freedom in the choice of test-points, and they are usually selected at equal wavelength spacings, regardless of whether the spectrum is formed from a prism or a grating. In dealing with a discontinuous spectrum no section of the spectrum must be omitted; otherwise an important band might be missed.

There are at least two kinds of spectrophotometric curves that should always be plotted to an absolute scale, namely, curves of reflectivity and transmissivity. Obviously if this is not done it is difficult to draw any definite conclusion from the results. Another practice that is apt to be a source of annoyance is the "suppressed zero." There are cases where this method is useful, for example if the data are concentrated between 80 and 90 per cent. it is unnecessary to show the blank space from zero to 80 per cent. and better to devote space to the particular region studied so that observations are plotted on a large scale. But in general it is best to avoid the suppressed zero, especially when only a few divisions are omitted so that the scale reads, say, from 20 to 100 instead of from 0 to 100. In these circumstances the method prevents the general effect of the curve being properly presented and is liable to cause confusion.

In making tests of the transmissivity of glass the correction for surface losses must be considered. With a refractive index of 1·52 this loss is such as to give a net transmission of 0·916 for perfectly clear glass. In dealing with a small thickness of glass this is particularly important. Thus if one sample gives a result 0·900 and another sample 0·884 the second absorbs *twice* as much light as the first (not 11·6 as compared with 10 per cent.).

THE LIGHTING OF KINEMA STUDIOS.

In a paper read before the Société Française des Électriciens, M. Pierre Bossu recently discussed the problem of artificial lighting in kinema studios. Many of his conclusions are substantially in accord with those reached by the Illuminating Engineering Society. Possible injuries are divided into irritation of the skin and prejudicial effects on the eyes, and may be ascribed to excessive ultra-violet light at close quarters or "glare." The chief illuminants, including arc lamps, mercury vapour lamps and gasfilled incandescent lamps, are dealt with, and attention is drawn to the very powerful light of arc-projectors and to the fact that the electrodes in some cases contain materials to accentuate the ultra-violet light. For kinema work high actinic value is of prime importance. Another factor is *constancy* of the light, as fluctuations (such as those produced by a.c. arcs on low frequencies) are liable to interfere with records of moving figures.

Amongst precautions desirable to avoid possible injury to the eyes, the author suggests that the full lighting should only be used during the relatively small interval of time during which a scene is actually filmed. Seeing that the camera-lens in any case absorbs most of the ultra-violet rays, there seems no objection to screening sources with glass that impedes the passage of such radiation. It is also recognised that diffusion of light, reducing the glare of powerful sources, is usually desirable to obtain artistic effects. In conclusion, the author points out that the difficulties of kinema work would be considerably reduced if suitable panchromatic films, with a response throughout the spectrum similar to that of the human eye, could be evolved. Following the paper, some demonstrations with Gaumont films of this kind took place, and these appeared to yield promising results.

SOME IMPRESSIONS OF THE SHIPPING, ENGINEERING AND MACHINERY EXHIBITION.

BY AN ENGINEERING CORRESPONDENT.

As usual, the above exhibition contained much of general interest but not a great deal bearing on illumination. The lighting of the exhibition was on familiar lines, without any very original or novel devices being evident. There were, however, fewer instances of glare than have been noted in some past exhibitions. Indeed in their zeal for shading some exhibitors adopted the rather singular step of using semi-indirect bowls, directing much of the light upwards to the far-distant ceiling of Olympia!

Among stalls which attracted attention one noted the effective concealed lighting of the *Motor Boat* and the restrained but pleasing effect of silk lanterns adopted by *The Engineer*. The semi-indirect lighting in the Lyons refreshment room by yellow silk shades was also effective. A few stalls utilised novel devices. The "Bitumastic" luminous sign, against a background of factory chimneys with an artificial sunset, and the concealed lighting of a displayed engine painted white by the Ailsa Craig Motor Co. may be mentioned. There were also several firms who made good use of photographic positive views of their works, backed by translucent glass and illuminated from behind—quite an effective device.

Oxy-acetylene welding apparatus was well represented, at the stalls of Allen-Liversidge, Thorn & Hoddle and others, and the latter had an exhibit of a special generator mounted on a movable trolley. The Allen-Liversidge stall was equipped with typical Imperial flares. It may be recalled that a picture showing the use of such lights for unloading ships by night was recently reproduced in the ILLUMINATING ENGINEER.* The burner and reflector only are mounted high up on the masts, acetylene being led up from a generator or cylinder of dissolved gas on deck. The literature of this firm now illustrates two types of reflector, concentrating and diffusing. Fuller data in the form of polar curves and figures for candlepower would be useful. One very compact and convenient device shown was the "hurricane" lamp, the use of which is greatly simplified by incorporating a small cylinder of dissolved acetylene in the design.

Other forms of lamps on view included the Kitson incandescent oil units and the simple ship-lanterns burning oil shown by various firms. Messrs. Siemens Bros. & Co., Ltd., showed their navigation light indicator which was described not long ago before the Illuminating Engineering Society,† and also typical forms of incandescent lamps. The exhibit of the Fairless Engineering Supplies Co., Ltd. included many items that were noted last year in this journal, such as the anti-vibration discs used to support incandescent lamps liable to be subjected to shock, the locking device for electric lamps, and the large forms of reflectors used for railways, docks, etc. One interesting novelty is a new form of small reflector which, it is understood, has been specially devised for Admiralty requirements. This consists in a series of separated conical surfaces such that the reflector, besides concentrating most of the light downwards, allows a little to escape sideways. This, it is hoped, will overcome the chief drawback to the use of metal reflectors in some situations—namely, the tendency to illuminate the working area strongly but leave the upper part of the room in comparative darkness.

There were a few exhibits in the gallery dealing with lighting. Some pleasing forms of decorative portable lamps (Staines Art Ware) were shown by Burlectas Ltd., and it was explained that the heavy base of these would render them suitable for use on a ship even when it rolled considerably. Some

* June 1921, p. 153.

† See ILLUM. ENG., May 1921, p. 121.

models of lighthouses were shown by Trinity House, but these rather suffered eclipse owing to the fact that no provision for artificial light was made in the model, and also the general illumination at this point was not very high. One of the most pleasing exhibits was doubtless the "Internalite" sign shown by the K.F.M. Engineering Co., Ltd. This type of sign, utilising the effect of total reflection of light in plates of glass, will be familiar to many readers of the ILLUMINATING ENGINEER. Some convenient forms of illuminated direction signs suitable for use on board ship, as well as larger types equipped with colour-changing apparatus for general advertising, were shown. Several developments in detail have been made, notably the double sign with an illuminated device on both sides, surrounded by clear glass. Other novelties include some very compact forms of strip-lights which, it is hoped, will effectively solve the difficult problem of providing suitable concealed lighting for glass showcases, etc.

ILLUMINATING ENGINEERING SOCIETY, U.S.A.

Arrangements for Seventeenth Annual Convention.

FULLER particulars are now available of the proceedings at the above Convention to be held a Lake George, New York, which should be of considerable interest. The Presidential Address will be delivered by Mr. Ward Harrison, and the usual Reports dealing with Progress in Illumination, Nomenclature and Photometric Standards, etc., will be presented. There will also be reports by the Committees on Motor Vehicle Lighting Regulations, and Luminaire Design, etc.

The following is a list of some of the papers to be read :—

Pageant Street Lighting .. .. SAMUEL G. HIBBEN
The Relation of Illumination to Production .. D. P. HESS and WARD HARRISON
Salient Features of Power Station Lighting .. .. R. A. HOPKINS
A Night of Light and Colour (Spectacular Lighting Display) Designer Mr. M. LUCKIESH
Visibility of Radiant Energy .. .. .. K. S. GIBSON and E. P. T. TYNDALL
Some Experiments on the Speed of Vision .. .. .. PERCY W. COBB
Colorimetry and Photometry of Daylight and Incandescent Illuminants L. G. PRIEST
Further Studies of the Composition of Light on Important Ocular Functions .. .. C. E. FEREE and G. RAND
Artificial Illumination in the Iron and Steel Industry .. W. H. RADAMACHER
Working with the Architect on Difficult Lighting Problems .. .. A. D. CURTIS and J. L. STAIR
Railway Car Lighting .. .. G. E. HULSE
Depreciation of Lighting Equipment due to Dust and Dirt E. A. ANDERSON
Determination of Daylight Intensity at a Window Opening (Report of Committee on Sky Brightness) .. .. .. H. H. KIMBALL
Daylight from Windows .. .. .. H. H. HIGHBIE and G. W. YOUNGLOVE
Some Principles Governing Proper Utilisation of the Light of Day in Roof Fenestration .. .. W. S. BROWN
Lighting of School Buildings. Preliminary Draft of Revised Codes (Report of Committee on Lighting Legislation) .. .. L. B. MARKS
Coloured Light .. .. M. LUCKIESH
Production and Growth of Plants under Artificial Illumination R. B. HARVEY
The Response of Plants to Artificial Lighting .. .. .. HUGH FINDLAY
Unit Costs of Industrial Lighting .. .. DAVIS H. TUCK
Testing Coloured Materials for Fastness to Light .. .. .. H. S. THAYER

TOPICAL AND INDUSTRIAL SECTION.

[At the request of many of our readers we have extended the space devoted to this Section, and are open to receive for publication particulars of interesting installations, new developments in lamps, fixtures, and all kinds of apparatus connected with illumination.

The contents of these pages, in which is included information supplied by the makers, will, it is hoped, serve as a guide to recent commercial developments, and we welcome the receipt of all *bona-fide* information relating thereto.]

INCANDESCENT MANTLE MANUFACTURE.

Press Visit to the Welsbach Light Co.'s Factory, Wandsworth.

THE recent Press visit to the above factory was interesting as showing the great variety of processes (22 distinct operations) in mantle manufacture. The general nature of the work will be familiar to our readers. The first step is the knitting or weaving of stockings from the ramie yarn, or from artificial silk. We understand that very little of this work was done in England prior to the War, but at the Welsbach factories many machines for this purpose, producing a variety of fabrics, were seen in operation. The washing of the fabrics, first with acid and then with water, has to be carried out with scrupulous care, as the ash-content must not exceed 0·02 per cent. The material is partially dried in a centrifugal machine and then soaked in *distilled* water and the process continued until the fabric is completely freed from acid. Impregnating with the "lighting fluid" (ultimately leaving a skeleton consisting of 99 per cent. of thorium oxide and 1 per cent. of cerium oxide) was formerly done by hand, but is now done on special machines; the impregnated fabric being passed between rubber-covered rollers, adjusted both to remove all surplus fluid but to leave the correct weight for any mantle.

The impregnated fabric is then dried and cut into necessary lengths. Some extremely ingenious machines are used to fit the head with asbestos cord, subsequently gathered together to bunch the top of the mantle. The modelling and hand stretching of the mantle prior to burning is a skilful process that has much to do with the subsequent shape. Mantles are next suspended in frames and burnt off, the operator viewing the process behind panes of dark glass, and are subjected to a special seasoning and shaping process. Finally, there is the process of collodianising which gives strength to the fine structure of rare earths.

Many of these processes naturally vary slightly according to the type of the mantle, *e.g.*, whether upright or inverted. It may be noted that "soft" mantles of cotton, ramie or artificial silk are also made. There are, in fact, something like 1,000 different types of mantles made, ranging from the small inverted mantles, only 7/16 in. long and 5/16 in. in diameter, to the large types $3\frac{3}{8}$ in. long and nearly 2 in. in diameter. One upright type, with a length of 11 in. and a maximum width of over $5\frac{1}{4}$ in., used for lighthouse work, is stated to be the largest mantle in the world.

The processes of packing mantles in boxes has also been brought to an advanced stage, the automatic machines for cutting out and labelling the cylindrical boxes being particularly interesting. We understood that it is quite usual for the stock room to contain material for several millions of mantles. All mantles are carefully inspected and tested prior to packing and some were also shown being subjected to test by a machine administering shocks at regular intervals.

The works as a whole give one the impression of ample space, and the various rooms, all finished in white, receive

INDEX, July, 1923.

PAGE

Editorial. By L. GASTER 157

Engineering and Shipping Exhibition, Notes on the 180

Kinema Studios, The Lighting of 179

Illuminating Engineering Society—
(Founded in London, 1909)

Account of Annual Meeting 161

Report of Council for the Session November 1922—May, 1923 .. 163

The Spectro-Photometric Comparison of Artificial Daylight with Natural North Sky Light. By P. R. ORD 167

Discussion:—A. P. TROTTER—P. J. WALDRAM—J. S. DOW—P. R. ORD (in reply) 175

Illuminating Engineering Society, U.S.A., Forthcoming Convention 181

REVIEWS OF BOOKS AND PUBLICATIONS RECEIVED 184

Spectrophotometric Data, Plotting of 178

TOPICAL AND INDUSTRIAL SECTION 182

abundant daylight. The greater part of the factory is lighted by high-power overhead incandescent gas units, but it was interesting to observe that in certain sections, such as that devoted to collodianising, electric incandescent lamps in gas-proof globes are utilised; these, however, receive current from a special generating set run from gas engines.

Following the inspection of the works, the visitors were conveyed by motor to the Hotel Victoria, where they were entertained to luncheon. Mr. J. R. Yates, the Chairman, in a short address, mentioned that this was the first Press visit to the Welsbach Light Co.'s factory in the whole history of the undertaking. Mr. Yates gave some amusing illustrations of the extreme fragility of the early mantles, the first of which was brought over from Vienna in a bird cage, which never left the hand of the messenger until arrival. He quoted a remark by Lord Moulton to the effect that Welsbach, whose discovery had been made at such an opportune moment for the gas industry, should be regarded as one of the greatest benefactors of civilisation. A vote of thanks to the Chairman and to Mr. Talbot, Mr. Bark, Mr. Palmer and others who had contributed to the success of the visit, terminated the proceedings.

SIEMENS ELECTRIC LAMPS.

WE have received from Messrs. Siemens and English Electric Lamp Company, Ltd., a series of lists of standard carbon, tungsten (vacuum) and gasfilled lamps, attractively illustrated by photographs showing their applications for various purposes, *e.g.*, on tubes and railways, in theatres and on board ship.

Special interest attaches to the leaflets dealing with automobile headlight and projector lamps. The former are shown in great variety, and there is some useful introductory matter explaining how a headlight operates and how glare may best be avoided. The projector types for optical lanterns, cinematographs, flood-lighting, etc., deserve special notice and illustrate the progress that has been made in the manufacture of such special filaments.

REVIEWS OF BOOKS AND PUBLICATIONS RECEIVED.

The British Acetylene and Welding Handbook. (*Raggett and Co., London, W.C.* 1923.)

FOR some time there has been a need for an authoritative work covering the wide applications of acetylene, and the handbook prepared by a committee of the British Acetylene and Welding Association should prove most useful.

A number of leading experts collaborate. Thus the introductory historical, chemical and physical notes are by Mr. W. J. Atkinson Butterfield, Mr. Arthur Stephenson deals with dissolved acetylene, Mr. A. Hoddle with acetylene lighting, and Mr. A. G. C. Lucas with various applications (*e.g.*, portable and emergency lamps, flares, searchlights, marine uses, welding, heating and cutting, etc.). Other chapters are specifically devoted to oxy-acetylene welding and cutting, generator specifications, etc. Not the least valuable section is that containing a comprehensive summary of statutory and official orders, regulations, etc., bearing on uses of acetylene. At the end of the book is a list of some of the chief works on acetylene. So far as the use of generators and the technical details of implements using acetylene are concerned, the information appears to be complete, but we think that the book would gain in value if, in the next edition, a little more was said in regard to the best methods of using acetylene to obtain good illumination. There are many principles of good lighting common to all illuminants, which might well be mentioned in a book of this description.

Annual Report of H.M. Chief Inspector of Factories for 1922. (*Cmd.* 1920. *Available from H.M. Stationery Office, London.* 5*s. net.*)

IN the General Report a special section is devoted to "safety" and reference is made to the good work of the Industrial Safety First Association. The number of reported accidents (97,986) is slightly greater than in 1921, but this apparent increase is attributed to trade conditions. Other sections deal with dangerous trades, sanitation, and employment. The references to the importance of lighting are dealt with elsewhere in this issue (p. 160). Reports by the Senior Medical Electrical and Engineering Inspectors are included. There is also an account of an investigation into the Dust Content of the Atmosphere of Workplaces, and an interesting study of the Comparative Physiological Costs of Different Methods of Weight-carrying. Accidents are tabulated in considerable detail in the statistical appendix.

Second Report of the Miners' Nystagmus Committee. (*Issued by the Medical Research Council and available from H.M. Stationery Office.* 9*d. net.*)

IT will be recalled that the Committee, in their first report, dealt with nystagmus as an occupational disease, and discussed its causes, amongst which inadequate illumination was found to be the most important factor. The present report deals with incapacity resulting from miners' nystagmus in more detail, and analyses present procedure under the Workmen's Compensation Act. One interesting conclusion is that errors of refraction have no direct influence on the disease.

The Electrical Contractor's Year Book (1923-24.)

THE Electrical Contractor's Year Book for 1923-24 contains a complete list of members and a brief history of the Association. The President's report states that the past year has been one of depression, but matters are now improving, and meantime the membership has considerably advanced. It is interesting to note that a sign is in preparation for the use of members on their stationery, etc., as a means of identification.

Particulars are also given of the work of the British Engineering Standards Association, and the British Electrical Development Association. There are also particulars of other trade bodies concerned with wages, etc., and the working rules of the various districts are set out. A useful item is the summary of the "Law of a Consumer's Right to the Supply of Electricity."

British Science Guild Publicity Service.

THE British Science Guild has taken an enterprising step in publishing readable pamphlets on recent scientific discoveries. We have received copies of Dr. J. A. Fleming's contribution on "Thermionic Valves and their Uses," and Sir Robert Hadfield's pamphlet on "The Discovery of Manganese Steel." Both are interesting and easily followed and should serve to illustrate the aims of the Guild.